Space Weather Technical Forecast

Issued on Monday, 22 April 2024 at 01:18 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares expected (R1/R2 blackouts). Slight chance isolated G1/Minor Storm intervals from peripheral CME effects.

Solar Activity: Moderate with three M-flares observed. Two impulsive flares, an M3.4 (at 21/2152 UTC) and an M2.2 (at 21/1514 UTC) from AR3638 in the southwest, and a longer period M1.0 from AR3645, one of the sunspots within the complex of sunspots in the southwest disc. There are seventeen sunspot regions. This includes a broad complex in the southwest disc, comprised of AR3638/45/47/43, and forms the main flare risk, despite their individual relative simplicity. This is due to an overarching magnetic structure connecting all the spots, as evidence on SDO imagery, along with some mixing of the magnetic polarities. These regions have shown some ongoing development, but any areal growth remains minimal with AR3643 showing signs of decay. AR3639 in the northwest is also moderately sized, but remains stable with a simple bipolar configuration. The most rapid growth was observed in AR3652 and AR3646 on the northeast disc, although these also remain simple and stable bipolar regions. Areas of flux emergence and subsequent spot growth also occurred on the southeast disc, however these spots remain small and simple.

The M-flares of AR3638 resulted in further weak and southward directed CMEs, which are still under analysis for any Earth-directed impacts.

Solar Wind / Geomagnetic Activity: Ongoing fast wind influence from CH25/- was likely through the period with solar wind speeds observed by ACE at L1 slightly elevated throughout, 420-480 km/s, albeit rather noisy to observe due to the below average density of the wind. Interplanetary Magnetic Field (IMF) Bt, was weak 2-8nT, with the north-south component, Bz, weakly negative (southward) for much of the period with minimum -6nT. Brief northward periods resulted in a maximum of 5nT. Phi angle was predominately negative (towards the Sun). Geomagnetic activity was Unsettled to Active (Kp3-4).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) observed at GOES18 was at Background. High energy electron flux (greater than 2MeV) observed at GOES16 was initially at Background, but rose to give a period of Moderate 21/1300-1900 UTC with peak 755 pfu at 21/1415 UTC. The associated 24-hour fluence remained below Active (1e8 integrated flux), but with a rising trend, reaching 8.55e6 integrated pfu at 22/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Occasional M-class flares are expected, with a slight chance of isolated X-class flares.

Solar Wind / Geomagnetic Activity: There are multiple CMEs that are expected to pass close to Earth through the period, but with the potential of giving glancing interactions. This gives low confidence to the detail for the geomagnetic forecast. Otherwise ongoing fast winds from CH25/- are expected to gradually ease, with solar wind speeds gradually easing from Slightly Elevated to Background. Quiet to Active geomagnetic activity at first is forecast to ease to be mainly Quiet with isolated Unsettled intervals by day 2 (23 Apr). Any CME arrivals however, will give a chance of further isolated Active intervals and a slight chance of briefly reaching G1 Minor Storm.

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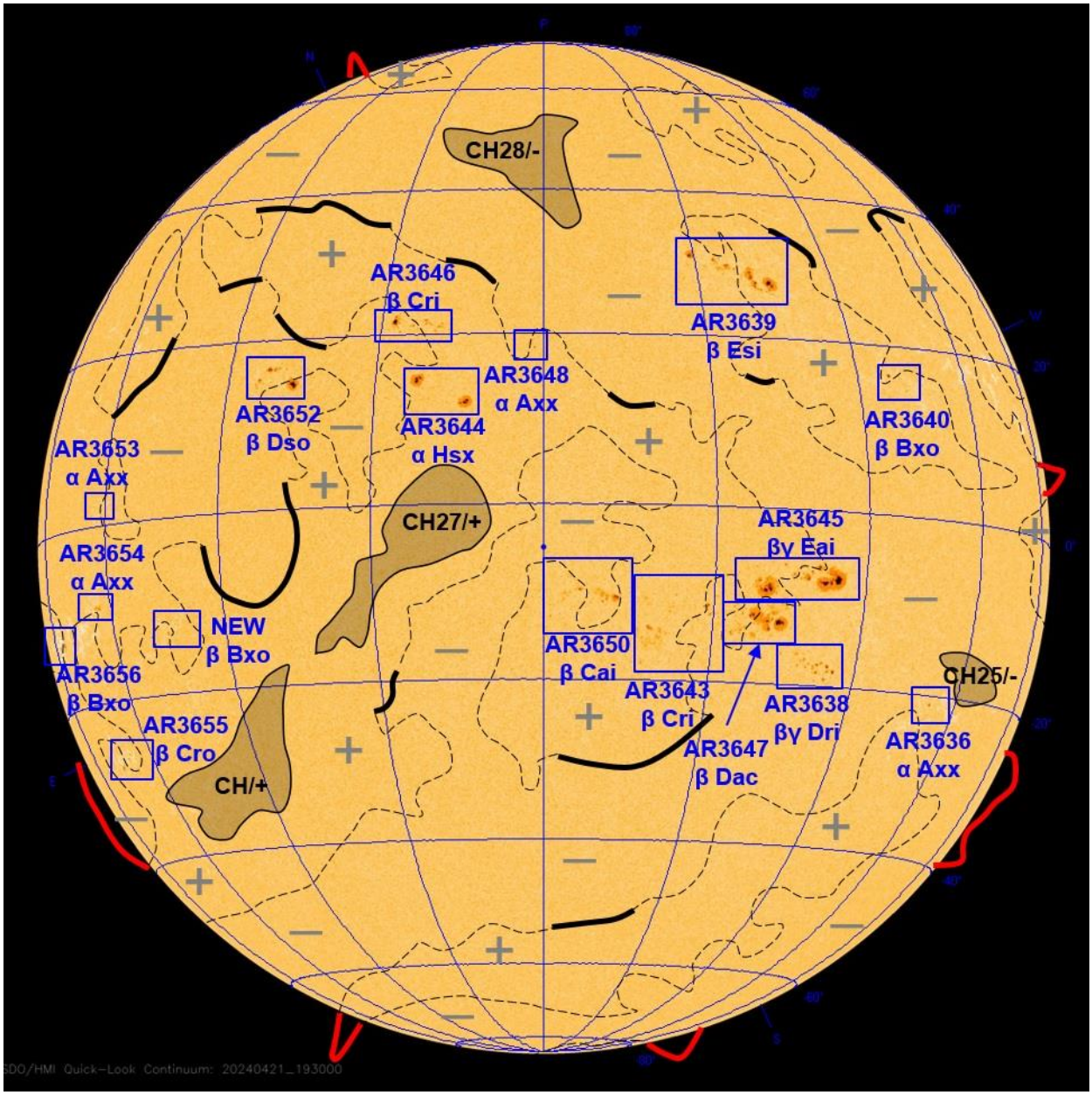
Energetic Particles / Solar Radiation: High energy proton flux is expected to be at background, but with a chance of rising in response to any large flares that occur, predominately from the complex of sunspots in the southwest. This bringing a slight chance of reaching the S1 Minor Radiation Storm threshold. High energy electron flux as observed by GOES16 is expected to showing a rising trend, to Moderate and peak High values, however this may be limited by any glancing CME impacts that occur. The associated 24-hour electron fluence is expected to remain below the Active (1e8 integrated pfu) threshold but with an increasing trend, giving a chance of reaching the Active threshold by the days 3-4 (25-26 Apr).

Figure 1. Solar Analysis Valid 21/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are multiple CMEs expected to pass close to Earth, and while many are likely to miss to the south, or be too weak for much of a noticeable impact, there is the potential for increase geomagnetic activity from any glance that occurs. These are mainly due to the number of weak ejections, primarily from narrow jet like eruptions from AR3638, but also other regions within the southwestern cluster of sunspot. However, it is difficult to isolate any single eruption as the main risk, with this potential continuing through the period.

Solar winds are expected to be slightly elevated at first, due to the waning connection of CH25/-, but these winds are expected to gradually ease to background slow wind conditions, as supported by MOSWOC Enlil.

Overall, geomagnetic activity is expected to be mainly Quiet to Active at first, but easing to mainly Quiet with isolated Unsettled intervals by day 2 (23 Apr). Any CME arrivals however, will give a chance of further isolated Active intervals and a slight chance of briefly reaching G1 Minor Storm.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	5	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

There are a number of weak CMEs either passing close to, or giving glancing interactions at Earth. These have occurred from 18-21 Apr, primarily from AR3638, but also other regions within the southern disc. These all combine to give a broad range of potential glancing impacts, as shown in the ensemble in figure 2 below, with further CMEs from the 21 Apr still yet to be assessed

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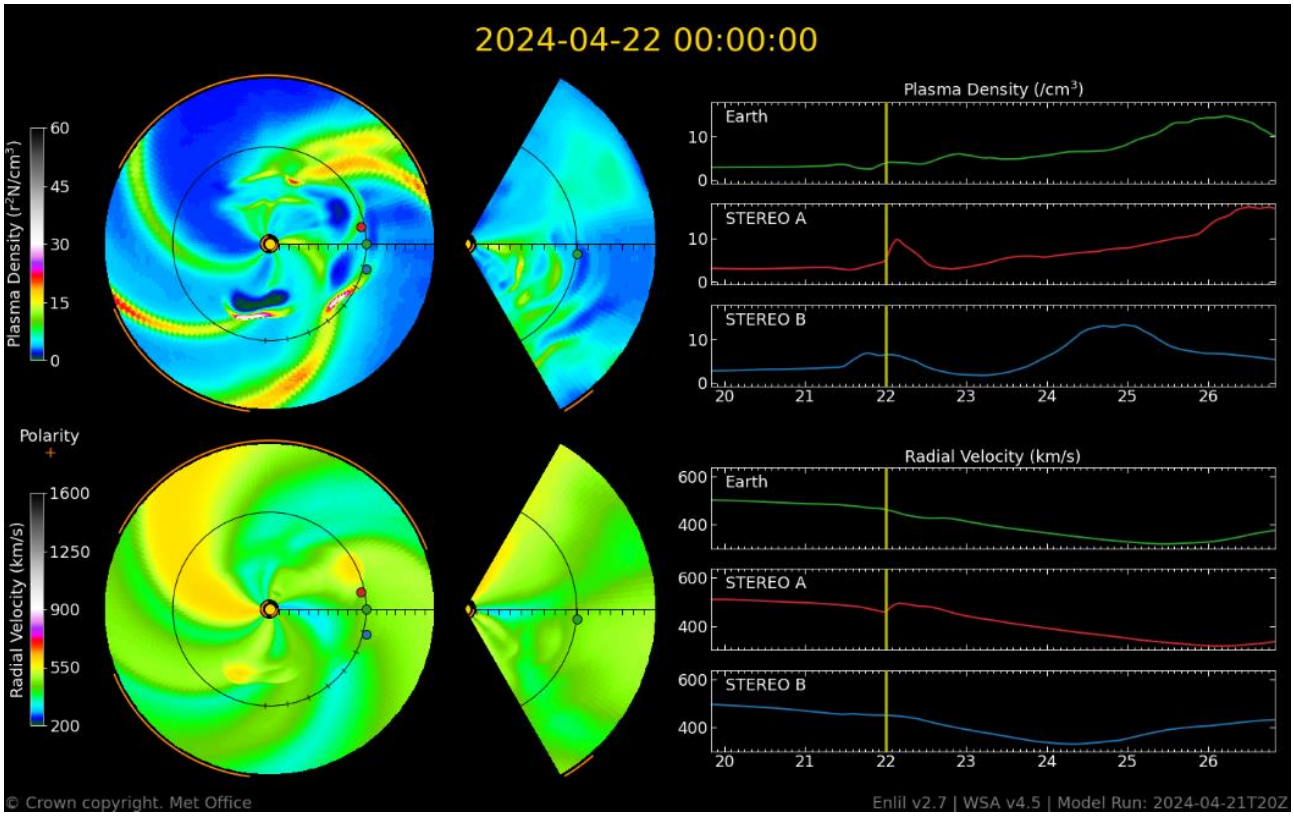
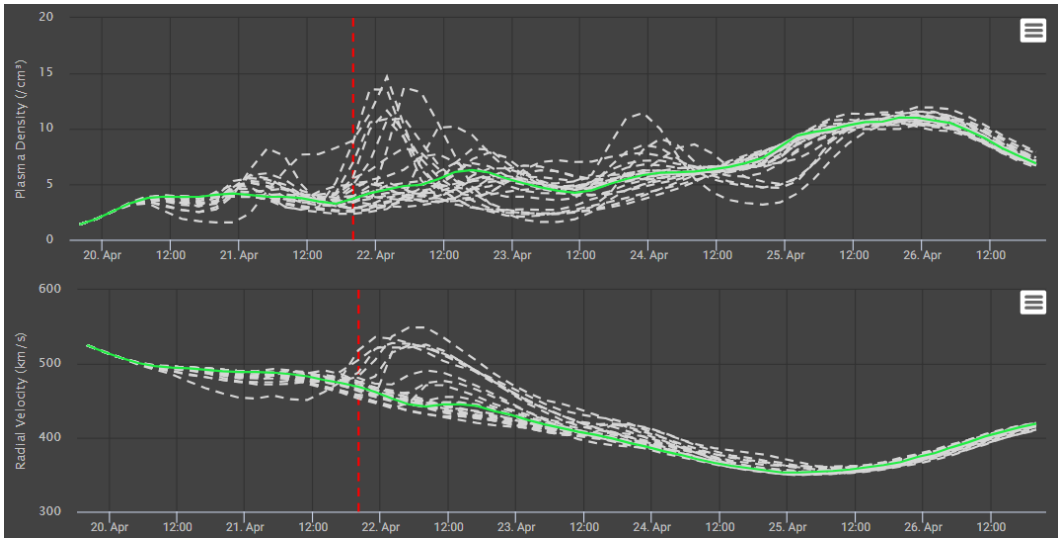
Figure 2 MOSWOC Enlil and ensemble:





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Radio Blackouts - X-Ray Flares:

Moderate activity is expected, with further occasional M-class flares expected and a slight chance of X-class flares.

There are seventeen sunspot regions. This includes a broad complex in the southwest disc, including AR3638/45/47/43, which continue to collectively provide the main flare risk, despite their individual relative simplicity. This is due to an overarching magnetic structure connecting all the spots, as evidence on SDO imagery, along with some mixing of the magnetic polarities, although the majority of recent M-flares have been from AR3638. This region also includes the main X-flare potential.

AR3639 in the north is also moderately sized, but remains stable with a simple bipolar configuration. A number of small, simpler spots are also present on the northeast disc, including AR3652 which recently emerged and is showing rapid growth. Small areas of flux emergence and spot growth are also visible in the southeast, with a number of new small regions recently numbered.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	75	75	70
Very Active	R3 to R5 X Class	No	15	15	10	10

Figure 3a: GOES-16/18 X-ray Flux

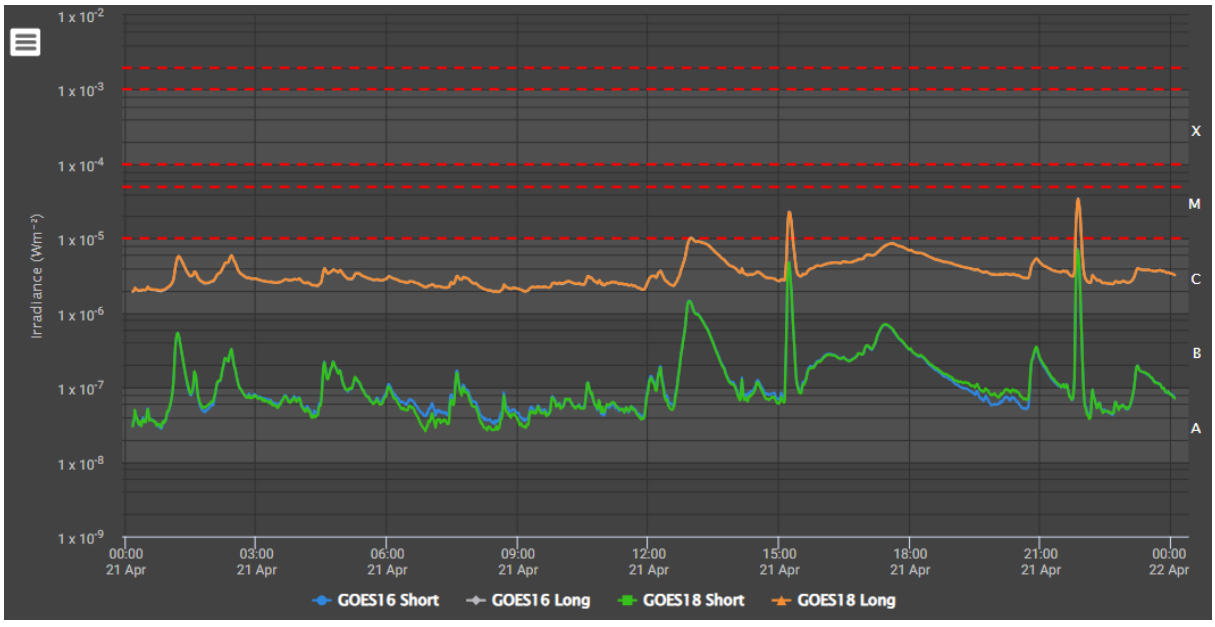

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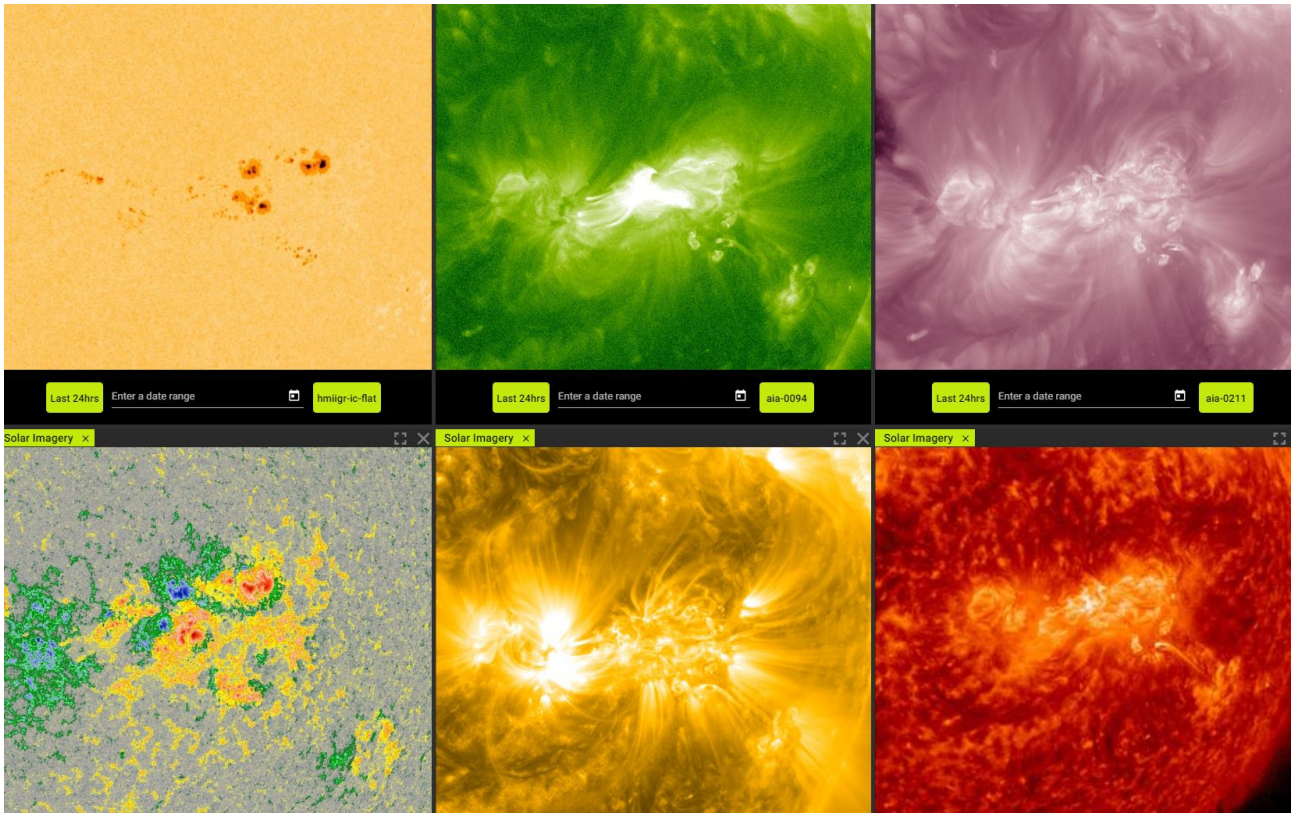
Figure 3b: SDO imagery of southwest sunspot complex



Solar Radiation Storms - (High Energy Protons):

High energy proton flux as observed by GOES18 has persisted at Background. There remains a slight chance of notable flare activity, primarily from the cluster of sunspot in the southwest disc, which could increase the proton flux at Earth. This bring a slight chance of reaching the S1 Minor Solar Radiation Storm level.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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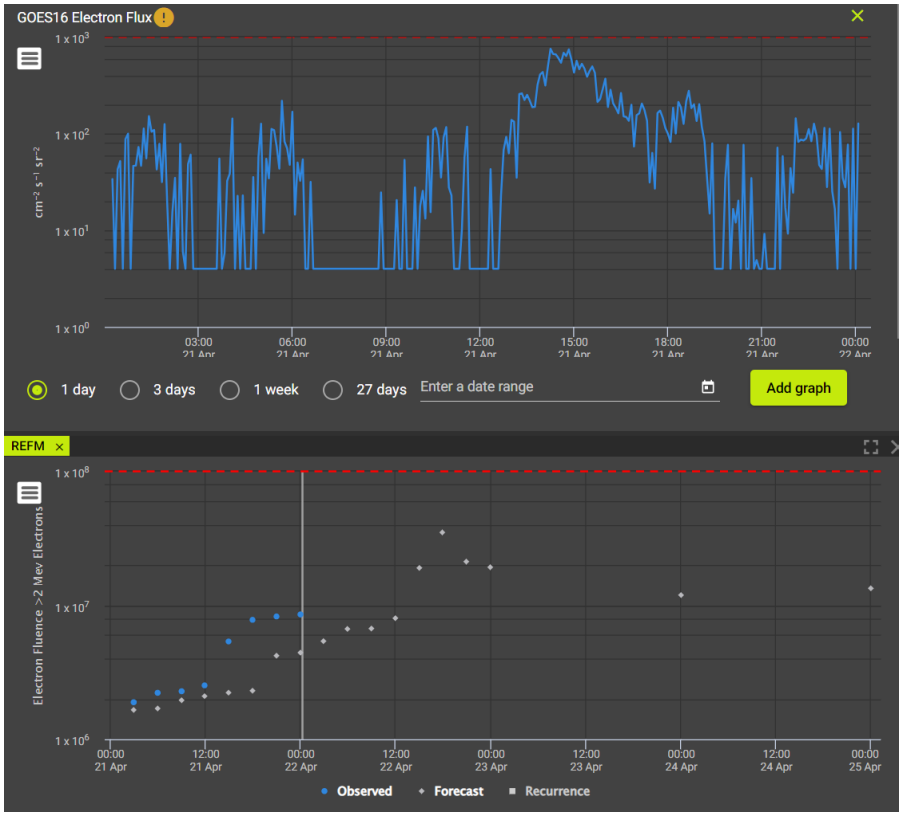
High Energy Electrons Event (≥ 2MeV):

High energy electron flux as observed by GOES16 rose from persistent Background to brief Moderate levels on 21 Apr, as a result of the recent CME arrival and CH HSS onset that had been observed on the previous days. As solar winds ease, any charging that has occurred at lower orbits is expected to become increasingly relevant at GEO, with the observed flux rising to Moderate and likely peaking at High for a brief period at diurnal maximum. This is only moderate confidence however, as the arrival of any CMEs may help to modulate the observed flux, and any more notable arrivals have the potential to drop values back towards background.

The associated 24 hour electron fluence is expected to continue on an upward trend, as indicated by REFM, which is giving a good guide in the absence of any CME arrivals, but perhaps under-estimating peak values a little. This will give a slight, but increasing chance of reaching the Active threshold by day 3 (24 Apr), although this potential will reduce should any dropout from any CME arrival occur.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	25	25
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: GOES-16 Electron Flux and associated 24 hr fluence with REFM



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